

served. On the east a luxuriant growth of grass is seen, and the gaudy flowers of the order *Compositæ* make the prairie landscape beautiful. Passing westward, species after species of luxuriant grass and brilliant flowering plants disappear; the ground gradually becomes naked, with "bunch" grasses here and there; now and then a thorny cactus is seen, and the yucca thrusts out its sharp bayonets. At the western margin of the zone the arid lands proper are reached. The winds, in their grand system of circulation from west to east, climb the western slope of the Rocky Mountains, and as they rise they are relieved of pressure and lose their specific heat, and at the same time discharge their moisture, and so the mountains are covered with snow. The winds thus dried roll down the eastern slope into lower altitudes, when the pressure increases and they are heated again. But now they are dry. Thus it is that hot, dry winds come, now and then, and here and there, to devastate the sub-humid lands, searing the vegetation and parching the soil. From causes not well understood the rainfall often descends in fierce torrents. So storms and siroccos alternately play over the land. Here critical climatic conditions prevail. In seasons of plenteous rain rich crops can be raised without irrigation. In seasons of drought the fields are desert. It is thus that irrigation, not always a necessity, is still an absolute condition of continued prosperity. The rainfall is almost sufficient, and the artificial supply needed is small — perhaps the crop will rarely need more than one irrigation. A small supply for this can be obtained from the sands of the river valleys that cross the belt. In some regions artesian waters are abundant; but the great supply must come from the storage of storm-waters. The hills and mesas of the region are well adapted to this end. Under such conditions

farming cannot be carried on in large continuous tracts.

Small areas, dependent on wells, sand-fountains, and ponds, must be cultivated. It is a region of country adapted to gardens, vineyards, and orchards. The hardier fruits can be cultivated at the north, and sub-tropical fruits at the south. From this region the towns and cities of the great valley and the capitals of trade in the East will be supplied with fruit and vegetables. It is the region of irrigation nearest to them, where gardens and fields produce richer, sweeter products than those of humid lands. Already the people are coming to a knowledge of this fact and are turning their industries in the right direction. The earliest settlements have been planted in seasons of maximum of rain, and the people who came had dreams of wealth to be gathered from vast wheatfields. Now wholesale farming is almost wholly abandoned. In the last twenty years, during which the writer has been familiar with the sub-humid zone, having crossed it many times and traversed it in many ways, he has seen in different portions two or three tides of emigration, each ultimately disastrous, wholly or in part, and settled regions have become unsettled by migration to other districts. But from each inflow a few wiser men have remained and conquered prosperity; and now that the conditions of success are known, he is willing to prophesy — not from occult wisdom, but from a basis of fact — that the sub-humid region will soon become prosperous and wealthy.

The Arid Land is a vast region. Its mountains gleam in crystal rime, its forests are stately, and its valleys are beautiful; its cañons are made glad with the music of falling waters, its skies are clear, its air is salubrious, and it is already the home of millions of the most energetic men the world has ever known.

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## MEMORY.



SOME years since, Francis Galton, in a most worthy-to-be-read essay upon twins, showed how the original fiber of the human individual asserts itself against training and environment. Nevertheless training and habit are potent factors in determining not only the action, but also the characters of individuals. This is so chiefly because the nervous system has been endowed with a faculty or attribute commonly spoken of as memory. To the consideration of this faculty the present article is devoted.

In entering upon the discussion of any subject it is essential first clearly to define the terms which are to be used. The big-headed, shaggy-locked founder of the English dictionary, Dr. Johnson, defines memory as the power of retaining and recollecting things past, and consciousness as the power of knowing one's own thoughts and actions. Probably he was in accord with the majority of mankind in associating consciousness and memory as two functions of the brain which are so inseparable that without consciousness there is no memory, and without memory there is no consciousness. This is, however, a mistaken idea.

Memory is really a function entirely apart from consciousness, and consciousness is distinct from memory; the two faculties dwell over against each other, but have no necessary connection.

If the spinal cord of a frog has been cut in the neck and its brain destroyed, its hind legs are of course separated from the brain in which consciousness exists. If one of the feet now be dipped into a dilute acid, the legs are immediately drawn up. This so-called reflex action is produced by the traveling of the irritation from the leg up the nerve to the spinal cord and the consequent excitement of the ganglionic or nerve cells in the spinal cord, which give rise to an outgoing impulse that travels back along the nerve and causes the muscles to contract. If now a little acid be dropped upon the end of the back, the frog will try to brush it off with the foot handiest to the position. If this foot be cut off, the animal will endeavor to brush off the irritating acid with the stump, and failing to reach the part will remove the irritant with the other foot. There is no consciousness in the frog. If it be put in a vessel of water, the liquid may be gradually brought to the boiling point without any sign of life or feeling being manifested. The brainless frog moves its foot because in successive generations whenever consciousness has recognized the existence of some irritant upon the back frogs have taken the leg and brushed off the irritant; in this way a habit of action has been formed, and in the fullness of time it has happened that whenever there is a point of irritation upon the back of the frog the leg responds to the irritation in a reflex manner through the spinal cord without the brain of necessity consciously recognizing the irritation. In other words, successive actions have registered themselves in the lower nerve centers, so that a peculiar irritation converts itself into apparently purposive muscular movement without the intervention of consciousness. The little spinal cell, whose power is manifested only in motion, has unconsciously remembered that in times past whenever a certain impulse has reached it from the surface of the body and passed upwards to be felt in the brain, it has in obedience to consciousness directly sent out certain nervous forces which have produced motion; and as the result of such unconscious recollection on the part of the spinal cell, motion is produced whenever the originating impulse is received by the cell, although consciousness has been abolished.

If the section of the nerve centers of the frog be made at such a position that it cuts off only the higher portions of the brain, in which consciousness resides, the frog is converted into an extraordinary automaton. If the foot of the frog be irritated, it moves it out

of the way; if the frog be thrown into water, it rushes in blind haste to and fro; if the water be heated, the frog crawls out up the side of the vessel in order to escape. There is every appearance of purposive action. If the frog be placed on the table and its back be gently stroked, there seems to come to it memories of happy courtship hours spent in swamp or bog, and it breaks forth into the love song so admirably paraphrased by Aristophanes as *βρεξε-κεκὲξ κοὰξ κοὰξ*. Yet the frog has not real consciousness. If food be placed before it, it pays no heed; though starving, it eats not, but dies of hunger in the midst of plenty. Unlike Tantalus, it is not tormented by ungratified desires, but perishes because it has no desires to gratify. If the food be put far back into its mouth so as to reach the gullet, the muscle contracts upon it and the morsel is swallowed, because the gullet has the unconscious memory of having swallowed when in the past food has been put into it. Once swallowed the food is digested, and the animal lives on. Put in the air and let alone, the frog is as a clod, until the sun withers it, and the wind blows it away. Without power to recall the past or to recognize the present, it sits motionless and mysterious as the Sphinx, buried not in the profundity of its thoughts, but in the abyss of its thoughtlessness. The movements of such a frog, whether those of swimming, climbing, or swallowing, are parallel with the simpler movements which occur in the frog whose cord has been cut lower down. The love song which it sings when stroked is the mechanical repetition of the expressions of its feelings through generations when replying to the caresses of its mate. The only difference between the two frogs is that in the second frog, in which the upper brain alone has been destroyed, the impulse traveling from the surface is able to pass a little higher up and reach not only the lower centers, but also those higher nerve centers which preside over more complicated movements.

In a similar way men and animals may walk on during sleep. A cavalry officer, speaking of one of the raids around Richmond during the Rebellion, said to me: "Successive days and nights we had been in the saddle, until from sheer exhaustion the whole regiment was asleep. The horses slept as they staggered on, the men slept in their saddles; but with the rebels behind and hope in front the whole command steadily marched onward." At every turn in the road it was necessary to station sentinels to waken horses and riders, who otherwise would have gone straight onward into fences, ditches, or mayhap over a precipice. "Indeed," said the officer, "I had a friend whose horse did walk with him into an abrupt abyss."

There was no upper brain memory of the past, no consciousness of the present, in that automatic mass of man and horse, which, though sleeping, walked forward by virtue of the recollection which lay in the lower nerve centers.

Memory is, then, entirely apart from consciousness. It is a function of nervous matter to be impressed with its own actions. If a nerve cell has once acted, it has a tendency to act again in a similar manner. If this action has been sufficiently repeated, the memory of it becomes stamped upon the little cell, and that stamp remains and dominates that cell. As a result of the influence exerted upon the cell, there has been formed, so to speak, a mold of that influence, by virtue of which, when the stimulation again comes, the cell reacts as it formerly had done. It is this fact which makes the training of children possible, and it is this that makes the responsibility of training children so terrible. Fixed habits are but the expression of organic form in nerve cells. We see this in disease as well as in health. A child receives a blow upon the head, and notwithstanding the healing of the cut there is still irritation of a peripheral nerve by a piece of stone or other foreign body left in the wound. Epileptiform convulsions result. The surgeon fails to recognize the cause of the trouble, and the convulsions are frequently repeated, until perhaps a wiser doctor sees and removes the irritating matter. Yet the convulsions go on. If the operation had been done early the child would have been saved, but it is too late. The nerve cells have had the convulsive stamp impressed upon them, and there is no power given to man to fill up the deep places or plane down the projecting corners of the mold.

If the sciatic or big leg-nerve of a guinea-pig be cut, the skin of a certain region of the face sensibly alters in structure, and epileptiform convulsions occur whenever any of this altered skin is irritated. If the affected skin be now cut out, the convulsions cease; but if the convulsions be allowed to continue, the habit is stamped not only on the mother guinea-pig on whom the original operation was performed, but on generation after generation of guinea-pigs. The memory of the nervous tissue for disease has been so terribly true that it has transmitted itself through successive generations.

A case which occurred some years ago in Philadelphia further illustrates the separateness of the higher intellectual memory from consciousness. A very old woman was dying; as the shadows of death gathered about her, she sat propped up in bed, holding her hands extended in front of her as though reading from a book, and speaking a jargon of words which no one could understand. At last one

well versed in languages came and said, "She is repeating the Portuguese Bible." When her history was inquired into it was learned that until the age of five or six years she had lived in Rio Janeiro, and no doubt had frequently heard the Portuguese Bible read; but during the many decades which she had resided in Philadelphia she had neither spoken nor read Portuguese. Yet when the veil was being torn off, when consciousness had already gone, and the lower nerve cells had power to assert themselves, there came forth, clear and sharp, the words that had been read in her presence when, a little toddling girl, she had haunted the streets and houses of Rio Janeiro. The sound had left its impress on the nerve cells as the type does upon the paper. Thus it is that in the presence of death a panorama of the past flashes with the velocity of thought before the consciousness. All persons are consciously and unconsciously molding in their brain cells records innumerable. Things that we reckon not of leave their impress there; stamp comes upon stamp like the various writings in an old palimpsest, in which the lower writings seem entirely obliterated until they are revealed by the processes of the antiquarian. So when the vision of the higher centers is sharpest it can see through the maze, and it may be in a moment decipher the records of a lifetime; or, when the restraining influence of the higher centers has been removed during delirious unconsciousness, muttered words, broken sentences, or clearly spoken periods, and mayhap even acts, give to bystanders glimpses of the passing visions.

Recently there has come to my notice the case of a man who under the influence of disease has recurrent visions of various character. Among these is a crescent of burnished silver from which dangle faces in great number; some unknown, some recognized by consciousness as those of acquaintances who had long passed out of recollection. As some of the faces were recognized only with difficulty, it is more than probable that the strange countenances were those of persons who had been previously seen, but the connection of whose impression upon the lower centers with consciousness was originally so faint or had been so long neglected that the thread could not be reunited. This case surely shows that physical shapes stamp their finest impression upon nerve centers, and that such stamp may be widely separated from conscious recollection and yet be firmly held through the years.

A little while ago I met a Quaker gentleman whom I had known in youth and I said to him, "Good morning." He gave me no answer. I said again, "Good morning, Mr. Jones!" He then said, "Horatio, excuse me,

I did not hear thee the first time." I asked him, "If you did not hear me the first time, how did you know that I had spoken?" What had happened was exactly this: there had been an impress made on the lower centers of that man's brain by my first salutation, but the impress had not been sufficiently strong to attract his attention. When his consciousness was awakened by my second salutation it looked down and saw the faint impression made upon the lower centers a moment before. That impress had been left permanently, although unnoted.

When we are trying to recollect a thing, we are simply searching here and there among the records in the brain to see if by chance we can find the leaf that we want to read.

What an index catalogue is to the searchers in a library, that to the searcher of brain records are the laws of association; and precisely as a purely alphabetical or arbitrary catalogue may assist the student, so may an artificial system of mnemonics assist the brain-delver.

The separateness of memory and consciousness is also illustrated by some of the extraordinary phenomena which are connected with the so-called local memories. Among the local or isolated memories the most distinct and sharply cut is the memory for words. It is entirely separate from the memory for things. As an instance showing this, I may cite the case of my own daughter, who when learning to read would recollect words as things, but not as words. She would say "b-e-a-u-t-i-f-u-l—handsome, pretty, good-looking." The meaning of this congregation of letters she could remember, but not the name of it. It is curious to note that this failure to remember names is in this case a clearly inherited mental defect.

When disease affects the brain these alterations of word-memory are something very strange. In the most complete form of this so-called aphasia the person cannot understand words, he cannot think in words, and cannot talk words. Usually, however, words are remembered sufficiently to be recognized when heard or seen, but although the idea is there, the person cannot speak in words. I recall the case of an old German woman who had aphasia. When asked how old she was, she would indicate sixty with her fingers. If asked how many children she had had, she would indicate seven. If two of the fingers were turned

down she would get angry and insist on the seven. She was able to understand questions. She knew what the figure "7" meant, but had not the power to say the word "seven." It is a very curious fact that in these forms of aphasia the language of the emotions may be preserved while the language of the intellect is destroyed. Very often a profane man, when he has aphasia, is able to swear. This German woman, when excited, could say "Gott in himmel!" Besides this there was left to her but one little fragment of each of the two languages which she had known. She could not say the English "no," but could say the German "nein"; she could not say the German "yah," but could splutter out the English "yes."

The forms of aphasia known as word-blindness and word-deafness are very strange. The sufferer from word-blindness can write and will understand what is said to him; he will talk to you and perhaps talk you to death; but hand him a book, a newspaper, or even the letter he himself has written, and he cannot read a word. Thus an active man of business having written a letter, giving directions for an important matter, attempted to read it, in order to see if it was correct, but was astounded to find that he could not make out a single word; he had been suddenly stricken with word-blindness. The sounds of the words and the words themselves had remained to him, but the recollection of the written forms of the words was gone.

In a case of word-deafness the person can talk and can write, but although his hearing is perfect he cannot recognize the spoken words. The sound of the voice is plain to his sense, but conveys no thought to him.

The records of the past—the unconscious memory, so to speak—exist in the brain; but for conscious recognition these must be dragged out before the consciousness. It is doubtful whether there is such a thing as a bad memory, *i. e.*, as a badly kept brain record. The difference in individuals as to the power of recollecting probably consists in the relation between consciousness and memory. One man has the power of going into the library in his brain and picking up at once the leaf he wants, and glories in his good memory. Another cannot in a moment find what he desires, but when the floods of disease come, then spontaneously float up those things which he had thought were gone forever.

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